

Modeling Knife

OPTIONAL

TOOLS YOU WILL NEED :

REQUIRED

Ruler
Scissors
Clear Tape
White Glue

X-24 BUC

Centuri

X-24 BUC

FLYING
MODEL
ROCKET

- Lifting-Body Principle
- Weird & Different
- Sweeping-Glide Recovery
- All Parts Pre-Painted



#5012

RECOMMENDED
ENGINESNot included
B4-2 C6-3 C6-0

SPECIFICATIONS

Length 7"
Wing Span 7"
Net Wt. 1oz.

Centuri

Made in U.S.A. Centuri, Phoenix, Arizona

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SKILL LEVEL

B	100	C	200
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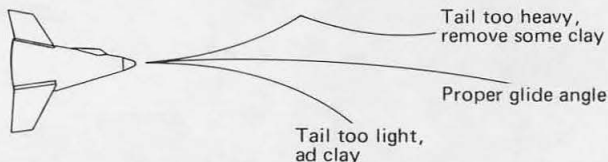
Engine Feet Engine Feet

Altitudes depend greatly on the quality of assembly and finishing.

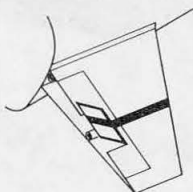
TYPICAL ALTITUDES

1 MODEL KIT
Paint and Glue not included.
1 MODÈLE RÉDUIT
Peinture et Colle non comprises.

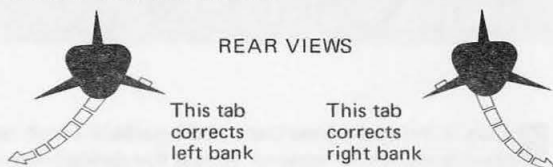
- E. Hold the Bug gently by its nose and throw it straight out from shoulder height. Try this several times to develop an even, gentle throw. Notice how the Bug falls. If it noses in a little sharply, add a little clay. If it climbs and stalls, remove a little clay. Add or subtract clay until you obtain a nice glide of about 10 or 15 feet.



- F. If the Bug banks sharply left or right, it is probably due to one fin being slightly crooked. You may correct banking by using trim tabs. Simply cut slits along the appropriate printed tab on the top surface of the wing. Lift tab gently away from where it may be glued to the lug.



- G. Adjust tab to prevent banking. If the Bug banks to the left, cut and raise the right tab slightly. If it banks right, raise the left tab. Final adjustments can be made after launching and observing the glide. The Bug is durable and will absorb fairly hard impacts.



- H. Once a proper glide has been obtained, smooth the clay into a neat flat "pancake" to secure it onto the Bug. Smear film of glue over the clay and body area.

ENGINES

Igniters and complete engine installation instructions are included in "Engine Operating Instructions" which accompany all Centuri engines.

Launch the X-24 BUG with the following engines.

- B4-2 MEDIUM ALTITUDE** — for general flying and smaller launch areas.
- C6-3 HIGH ALTITUDE** — for high flights and medium launch areas.
- C6-0 EXPERIMENTAL** — this booster engine may be used by itself in the Bug for unusual, short duration flights. It will normally eject itself when propellant burns through.

FLIGHT PREPARATION

- A. Brush any accumulated ejection material out of engine tube.
- B. Check gliding ability by hand launching.
- C. Prepare engine and igniter.
- D. Engine should be able to pull out easily, but should not fall out of its own weight. If necessary, wrap engine with a little tape.
- E. Attach launcher clips onto igniter, as close to nozzle as possible. Hold launcher off the ground to get a good view up into the Bug as you work. Straightened out paper clips may be used as igniter extensions if you find it difficult to attach clips.

Launch the X-24 BUG from any standard model rocket launcher having a 1/8" diameter x 36" long steel launch rod.

Referring to the specific instructions which accompany Centuri launchers and firing panels, mount the rocket on the launcher and prepare for ignition. Avoid eye injury by capping the exposed tip of the launch rod when not actually launching! Follow the instructions and the Safety Code, and have many happy hours with Model Rocketry.



Rod

X-24 "Bug"

Here is a model rocket version of a spacecraft of tomorrow! The X-24 Bug has a unique shape and low center-of-gravity that causes it to glide back to Earth after engine ejection. The Bug's quick, nearly foolproof assembly produces a truly unusual boost-glider . . . perfect for demonstrations and learning basic principles of glide theory.

The Bug has a glide ratio of about 2:1, which makes it ideal for flying in small fields where a contest model might glide out of sight. The X-24 Bug's rugged good looks and durability make this one sweet little model.

This rocket is designed to be launched only from standard remote-controlled electrical launch systems. Always use the recommended engines. Comply with all Federal, State, and local laws.



Catalog No. KA-12



MODEL ROCKETEER'S SAFETY CODE

CONSTRUCTION

My model rockets will be made of only lightweight materials such as paper, wood, plastic, and thin metallic foils, with the exception of payloads and engine holders made of wirelike material.

ENGINES

I will use only pre-loaded factory made model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.

RECOVERY

I will always use a recovery system in my model rocket that will return them safely to the ground so that they may be flown again.

WEIGHT LIMITS

My model rocket will weigh no more than 453 grams (16 oz.) at liftoff, and the engines will contain no more than 113 (4 oz.) of propellant, as prescribed by Federal Regulations.

STABILITY

I will check the stability of my model rockets before their first flight except when launching models of already proven stability.

LAUNCHING SYSTEM

The system I use to launch my rockets will be remotely controlled and electrically operated, and will contain a switch that will return to "off" when released. I will remain at least 10 feet away from any rocket that is being launched.

LAUNCH SAFETY

I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.

LAUNCH AREA

My model rockets will always be launched from a cleared area, free of any easy-to-burn materials, and I will only use non-flammable recovery wadding in my rockets.

BLAST DEFLECTOR

My launcher will have a blast deflector device to prevent the engine exhaust from hitting the ground directly.

LAUNCH ROD

To prevent accidental eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launching rod. When my launcher is not in use I will always store it so that the launch rod is not in an upright position.

POWER LINES

I will never attempt to recover my rocket from a power line or other dangerous places.

LAUNCH TARGETS AND ANGLE

I will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.

PRE-LAUNCH TEST

When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

FLYING CONDITIONS

I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft or under any conditions which might be dangerous to people or property.

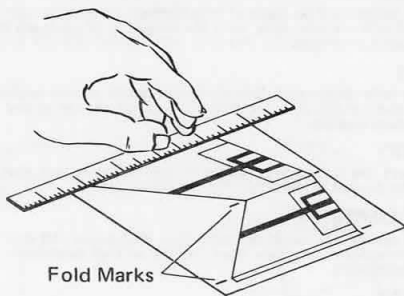
ASSEMBLY INSTRUCTIONS

TOOLS: In addition to the parts supplied, you will need the following tools to assemble and finish this kit. **DO NOT** use model airplane glue for building flying model rockets.

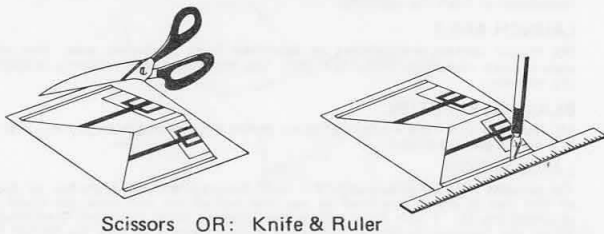


NOTE: It is to your advantage to read over all these instruction steps **BEFORE** starting assembly. Experienced rocketeers especially should read before building, because the assembly techniques are very different from those of standard model rockets.

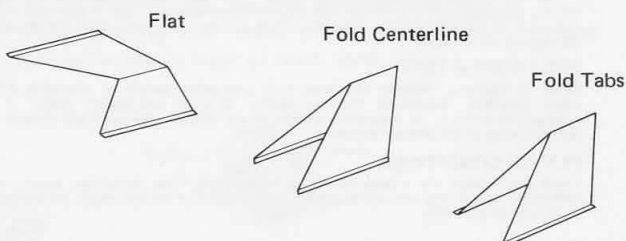
- 1 Several of the Bug's parts will be folded in later steps. Before cutting the wings and tail from their sheets, crease the indicated fold lines with a ruler and dull pointed object (such as a spoon edge, empty ballpoint pen, or very dull knife). Line the ruler up exactly with the fold marks and "draw" crease lines.



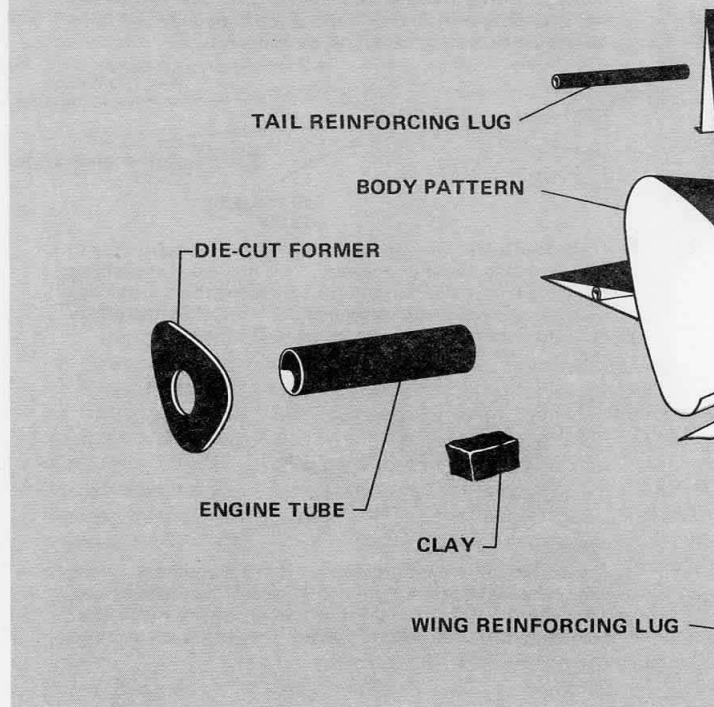
- 2 Cut out every paper part neatly, and with patience. These parts are designed with precision, and should be cut exactly on their outside edges and lines. Mistakes in cutting can be corrected with cellophane tape applied on the reverse of the pieces.



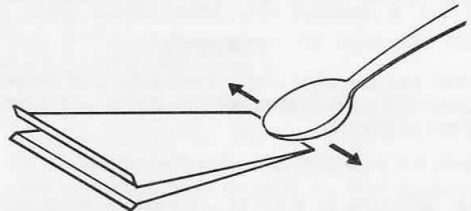
- 3 Fold the wings and tail along the lines you creased in step 1. Fold along the center line first, then fold each tab outwards.



CENTURI ENGINEERING COMPANY
P.O. Box 1988, Phoenix, Arizona 85001



- 4 Run a smooth, clean, rounded surface (such as your thumbnail or a spoon) along the folded creases to make them sharp and straight. Place the folded fins under a weight to allow the folds to "set up".

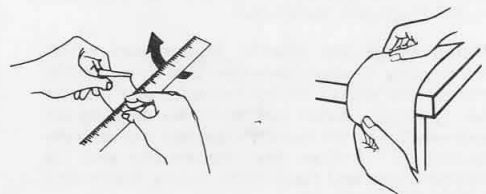


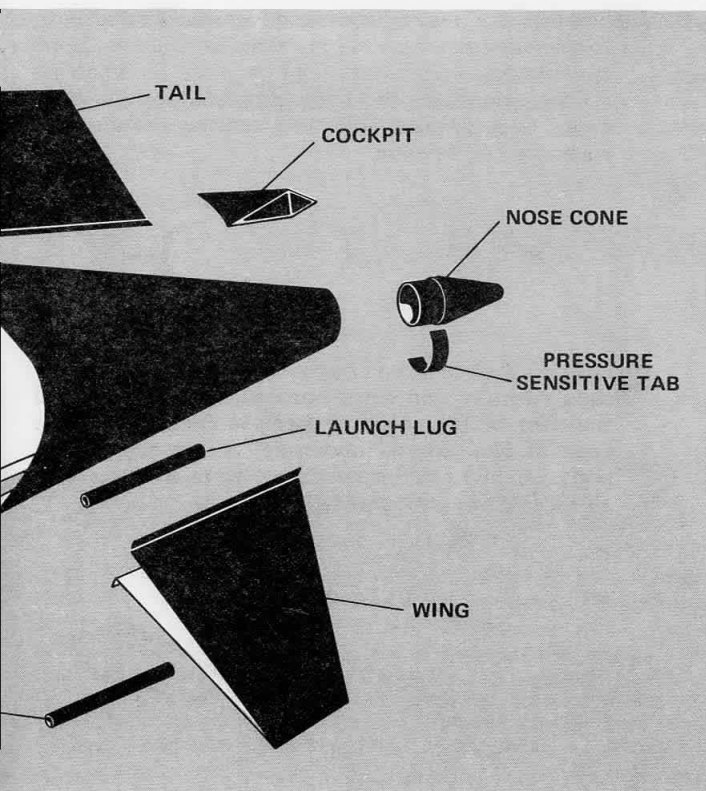
NOTE: READ STEPS 5 THROUGH 9 BEFORE ACTUALLY STARTING BODY ASSEMBLY.

- 5 If your hands are dirty at this point, wash and dry them thoroughly before proceeding. The cone section is pre-printed; if you get dirt smears on it, you may have to later paint the entire rocket for neat appearance.

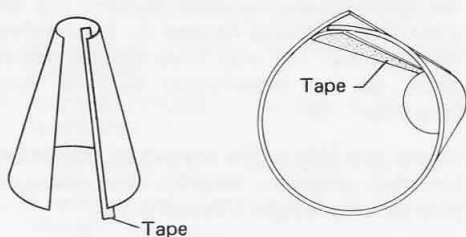
It's a good idea to keep a rag or paper towel handy for wiping glue off your hands as you work. This will keep the printed parts clean.

- 6 Pre-curl the body paper by running it under a straight edge on a clean flat surface, or over the edge of a table. Curl paper gradually to prevent creases from forming. The curling should form a neat cone.

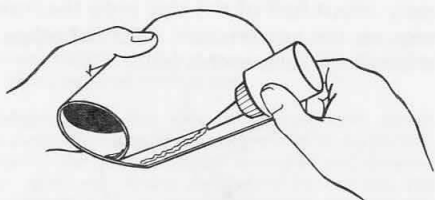




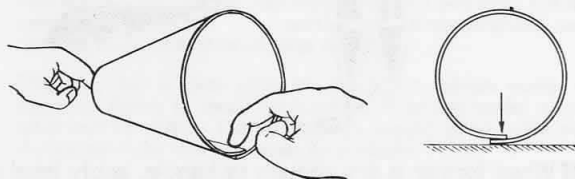
- 7** The cone will then sit by itself as shown. Gently form the cone (without gluing yet) to see how the edges overlap. Apply transparent tape the length of the entire glue tab as shown, on the inside of the cone. The tape is used to key the joint in place prior to any gluing. First, tack the small end of the cone together, then key in the large end, and finally connect the entire seam in its proper place. Be careful to line both sides so the two silver edges join neatly.



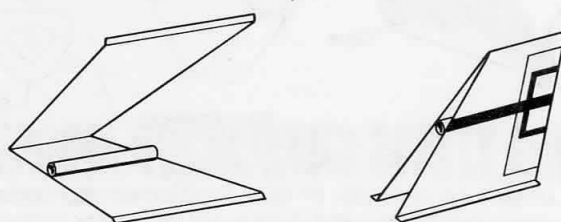
- 8** Now we are ready to do the actual gluing of the seam overlap area. Squeeze the cone together slightly to better expose the gluing surface. Run a bead of glue along the edge shown and immediately smooth it with your finger until just a thin film of glue covers most of the overlap tab. This way no blobs of glue will squeeze out and mar the pre-printed pattern.



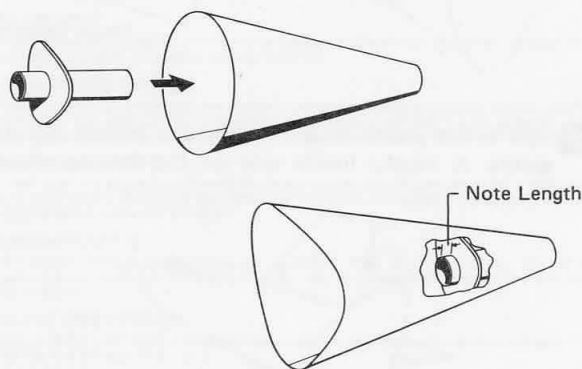
- 9** Push the joint against a table surface (protected by scrap paper). Slide your finger back and forth to insure that the entire overlap is bonded. Use eraser end of a pencil for the hard-to-reach part near the tip. Hold down for about 1 minute to allow time to dry sufficiently.



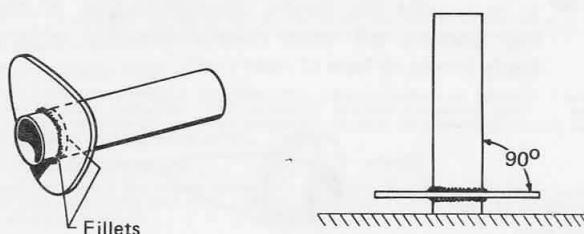
- 10** There are 4 launch lugs in your kit. Three will be used to reinforce the wings and tail. Apply a glue bead along one lug and position it on the reverse of a wing. Lugs should line up with the bold black lines running through middle of fins on the other side. Apply another glue bead to lug and fold fin gently onto it. Hold until glue starts to set. Repeat with other wing and tail.



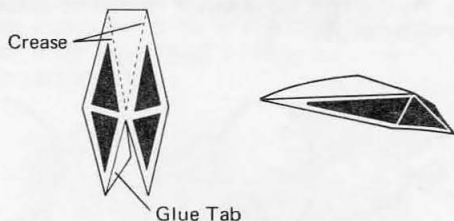
- 11** Slide the die-cut former over one end of the engine tube. Slide the assembly into the cone until tube is flush with the front of the cone. Gently push former until it neatly fills out the cone, and note how far it is from the rear end of the tube. This measurement will depend on how accurately the body was formed.



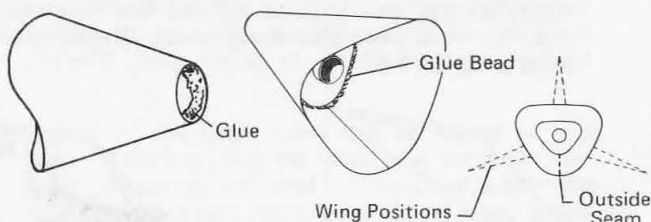
- 12** Remove assembly, and apply glue beads around tube — former joint, on both sides. Smooth into neat fillets with your finger. Stand assembly upright and allow to dry, checking alignment.



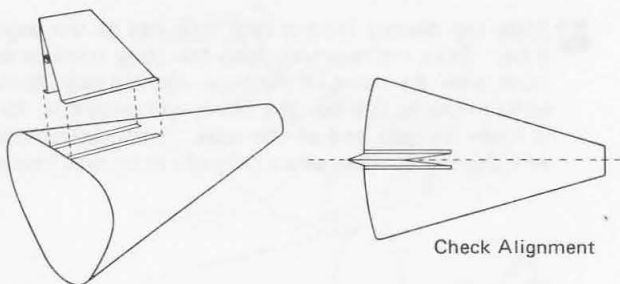
- 13** While waiting for the former to dry, assemble cockpit. Study the sketches below to understand how it is folded. Fold along crease lines, join glue tab, and hold until dry.



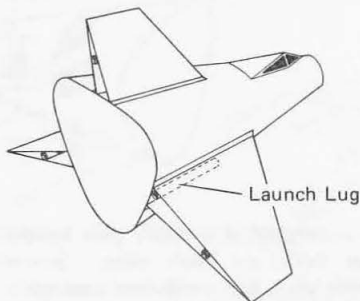
- 14** When former is dry enough to handle, apply bead of glue around inside front end of body cone. Insert former assembly until its tube is flush with front of cone. Be sure to align former shape with printed body. Apply thin bead of glue around former to secure it inside body mold until glue sets.



- 15** Glue the fins and tail on by applying a thin, even film of glue on underside of tabs. Position on appropriate areas, rub down, and hold until glue sets. Check alignment to be sure fins are on straight.



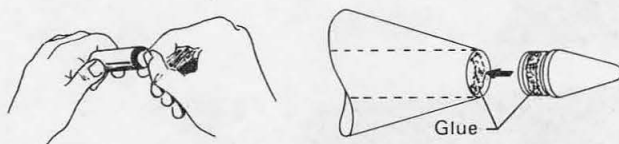
- 16** Apply thin beads of glue along the launch lug, and secure it neatly inside one of the fins as shown.



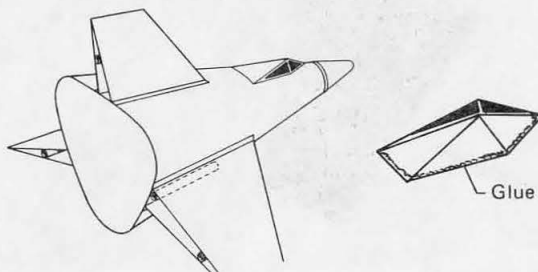
- 17** The plastic nose cone must be glued firmly in place to withstand the engine ejection charge in flight. Peel backing off small pressure-sensitive strip and apply firmly to base of nose cone.



- 18** Smooth the inside front edge of body tube with thumbnail to remove burrs. Test-fit the nose cone and remove. Glue nose cone in place by smearing a little glue inside the body tube and on nose cone base. Glue in place with firm, twisting motion, and wipe away excess glue.



- 19** Position the cockpit on the body to see how it fits . . . should form a thin white border on the body around the base of the cockpit. Remove cockpit, apply a bead of glue around underside, and re-position on body. Center cockpit neatly on white area and hold all edges down until glue sets.

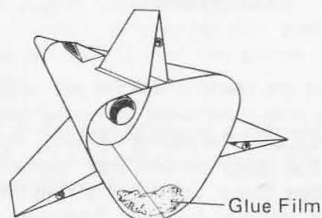


- 20** **OPTIONAL STEP:** You may wish to preserve the pre-colored Bug from stains and smears by spraying with a clear finish. Use light coats of any quality clear spray lacquer, plastic or artist's fixative.

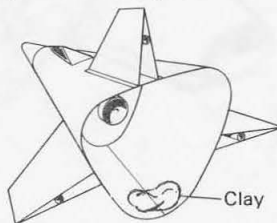
FLIGHT TRIMMING

Your Bug is now ready to have its final part added: The clay weight that will balance it for gliding. Follow these steps carefully to trim and test your model **BEFORE** launching it.

- A.** The Bug is not a contest endurance glider because it glides rather fast. No two Bugs will use exactly the same amount of clay, because the individual glide characteristics depend on the modeler's skill in assembly. If you have trouble adjusting its glide, ask an experienced airplane modeler to help you.
- B.** Smear glue into a film around the inside bottom of the body wrapper. When it dries, the surface will give the clay weight a better grip.



- C.** Choose a relatively calm day. Locate a clear, grassy area to test glide your ship.
- D.** Apply about half of the clay onto the inside of the body, at the bottom rear. Don't bother to make the clay look neat at this point.



MODEL ROCKET LIFTING BODIES



INTRODUCTION

A lifting body is basically an aircraft that generates aerodynamic lift by its shape, rather than the addition of an airfoiled wing. Lifting bodies that have small wings or fins generally use these only as control surfaces. The shape of a lifting body's fuselage determines its gliding abilities.

Real lifting bodies are used by NASA and other aerospace organizations to explore the possibilities of wingless flights. Different shapes are needed at different speeds. Some, like the Northrop Corporation's HL-10, are quite sophisticated manned vehicles with movable control surfaces and a rocket engine for powered flights. Others are unmanned mock-ups dropped from airplanes to observe gliding abilities. The lifting body principle has been used to slow the descent of returning spacecraft. The heat generated by friction during re-entry is spread out over the large area and thickness of the body. If wings were used at these high speeds, they would heat up too much and become unable to withstand the tremendous stresses of re-entry.

The Centuri X-24 Bug is used in this report as a model rocket employing principles of real lifting bodies.

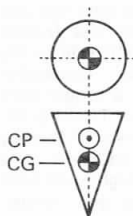
THEORY



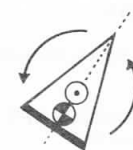
1. A falling piece of plain paper will not plummet straight to the ground like a rock. It tumbles and slips from side to side in an unpredictable and unstable flight path.



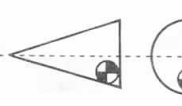
2. Now the paper is rolled into a cone shape. It will fall fairly straight, point first.



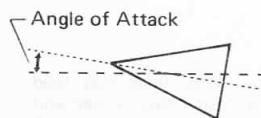
3. The cone's center-of-gravity (balance point) is ahead of its center-of-pressure (theoretical point where all aerodynamic forces seem to converge).



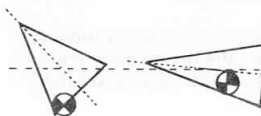
4. Adding a heavy circular base to the cone moves the CG behind the CP. The cone's shape makes it try to streamline in, but the rearward weight makes it try to fall tail first. These forces "fight" each other, and cause the cone to tumble as it falls.



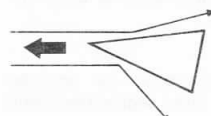
5. These two forces can be made to cooperate by moving the weight to one side, at the cone base.



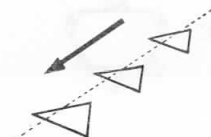
6. When the correct amount of weight is used, the nose cone will fall through the air with the nose pointing up, at a slight angle (called the angle of attack).



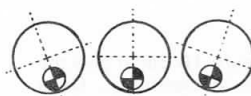
7. By moving the CG toward or away from the point of the cone, the angle of attack can be increased or decreased.



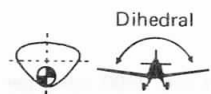
8. The cone moves through the air, creating resistance, or drag. The bottom surface is at a greater angle of attack than the top surface, therefore the bottom surface meets more air resistance.



9. The cone "rides" this air resistance down at a gradual angle, like a sled coasting downhill. This is a form of flat plate lift. While not as efficient as an airfoil, it allows a gradual, safe descent.



10. The cone still has a tendency to sway or roll from side to side as it descends.



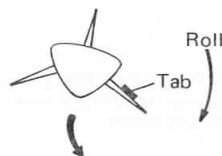
11. Changing the cone's cross section to a semi-triangular shape helps avoid roll. This is similar to the dihedral of airplane wings... the craft "settles" into a neutral middle position.



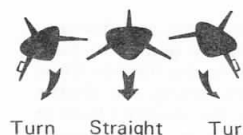
12. Placing the model rocket engine in the front of the cone makes it very stable in upward flight. CG is well ahead of CP.



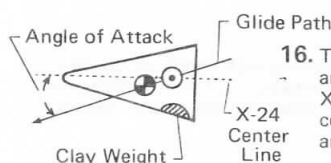
13. Fins are unnecessary for a gliding return. However addition of fins will stabilize the cone at engine ejection, and prevent it from being thrown end over end.



14. Bending up a tab on one wing creates drag on that side causing cone to roll. The roll causes the Bug flight path to veer towards tabbed side.

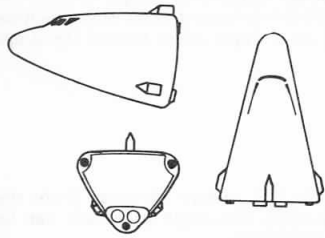


15. By rolling the cone in flight, cone can be steered to right or left. Tabs can also be used to cancel tendency to turn.



16. The engine ejects, causing the CG to shift down and to the rear. In glide configuration, the X-24 remains stable (CG ahead of CP), but off center CG forces the X-24 to fly at a positive angle of attack.

A REAL VEHICLE CONCEPT



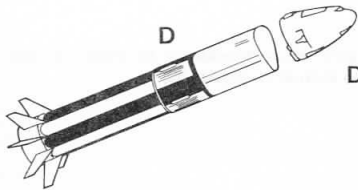
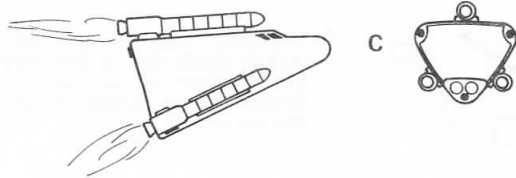
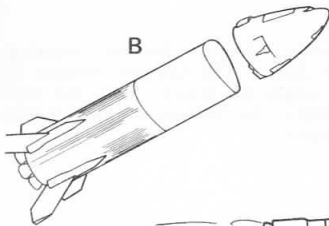
The variable CG lifting body as a Space Shuttle Orbiter

A NASA's lifting body tests may lead to Shuttle Craft for bearing men and supplies to orbiting space stations. A real Space Shuttle patterned after our lifting body model might have some important advantages.

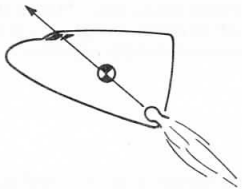
By the use of roll jets and a moving weight system, the lifting body could be controlled in both yaw and pitch.

B A large Apollo Little Joe type of rocket could boost shuttle craft for suborbital tests.

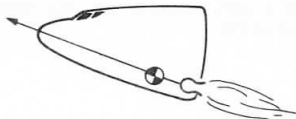
C Or the shuttle could be boosted by a cluster of large segmented solid fuel boosters.



D A modified Saturn 1B could give the lifting body orbital capability. Or, a Space Shuttle type of "mother ship" could be used for greater economy.



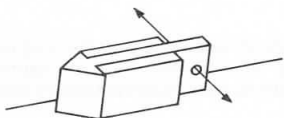
E At 40 miles up and 2800 miles per hour, the fully loaded shuttle (with its rocket engine mounted at the lowest point of the cone base) "crabs" at a negative angle of attack. In a vacuum this poses no problem.



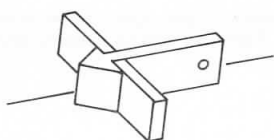
F With fuel almost gone, the shuttle's angle of attack approaches zero. Note that the rocket motor must thrust through the CG if the shuttle is to fly a straight course.



G Running along the belly of the shuttle, a sliding weight (not necessarily inert, perhaps one of the shuttle subsystems) changes the CG for pitch control during the gliding return.



H Reaction thrusters in small fins provide attitude control in zero G and yaw control during re-entry.



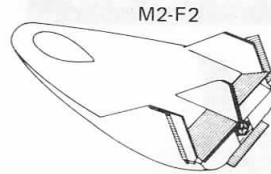
I Drag flaps extend from pods for control during subsonic glide. In both cases, movement to the right or left is accomplished by rolling the shuttle in flight so that the shuttle's built-in lift pulls to one side or the other.



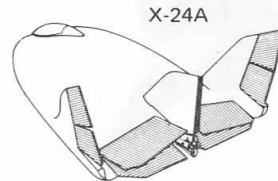
J The returning craft lands on conventional runways. Like an airliner, it will be prepared for more flights.

LIFTING BODY FLIGHT TEST VEHICLES*

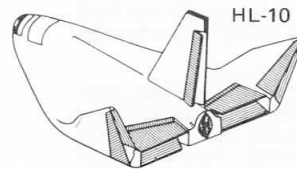
Here are three of the more famous actual lifting bodies tested by the U.S. Air Force and National Aeronautics and Space Administration.



Body Planform Area, ft.	160.0
Body Span, ft.	9.5
Body Length, ft.	22.0
Landing Weight, lb.	6150



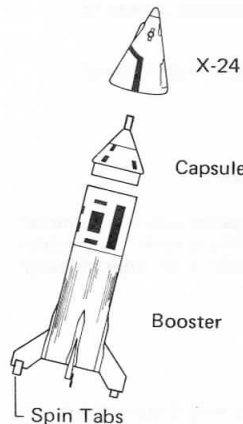
Body Planform Area, ft.	191.0
Body Span, ft.	13.5
Body Length, ft.	24.5
Landing Weight, lb.	6000



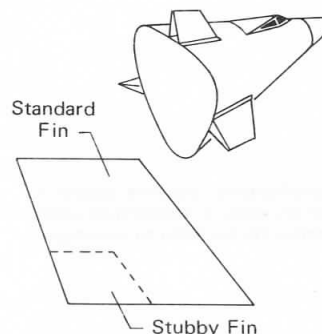
Body Planform Area, ft.	160.0
Body Span, ft.	14.5
Body Length, ft.	22.0
Landing Weight, lb.	6400

*Data and illustrations courtesy of American Institute of Aeronautics and Astronautics, AIAA Paper No. 71-310.

EXPERIMENTS WITH THE FINLESS X-24



The X-24 has been successfully flown without its stabilizer fins. At the peak of most finless flights, the ejection charge pushes the X-24 ahead so fast that it stalls and flips end over end. However, once in a stable glide, the X-24 is stable on all axes and glides well, sometimes rocking gently as it makes its descent. For higher and more dependable flights, the finless X-24 can be carried by a modified Centuri 1/45 scale Little Joe II. Simple paper spin tabs are added to one side of each fin to increase stability. The kit is built with 2" of #5 tube protruding from the capsule, instead of adding ladders and tower. The X-24 fits over the #5 tube, its base resting on the Apollo capsule. At chute ejection, the X-24 simply drops away and glides back.



SEMI-FINLESS BUG: The X-24 Bug type of model rocket lifting body may be modified for greater endurance and durability. The substitution of much smaller wings and tail will produce a vehicle with less frontal area, allowing greater altitude in the rocket-powered ascent. Generally, the body will glide for a longer time from the higher apogee. The shorter, stubbier fins also withstand landing impact better. The addition of a little more rearward weight will cock the body's nose up to give longer, more gradual gliding returns.

REFERENCES FOR FURTHER STUDY

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WINGED ROCKETRY
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"X-24 Bug"

—Do not fold

